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Experimental Verification of the Model for Calculating the Effect of Slope and Aspect Upon Grass Temperatures.

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SUMMARY

The output from a model for calculating Accumulated Temperatures (T-sums) on sloping surfaces at ground level has been compared with actual data from a hillside near Trawscoed in Wales. Measurements were made from January to June 1985. The model and actual Accumulated Temperature data are in good agreement for all three slopes tested - facing north, south and west. Further measurements will be needed to determine what fraction of the differences that occurred could be attributed to the model. In the meantime, the comparison has shown that the model is providing sufficiently accurate results for most applications.

1. Introduction

Lee (1984) described a model for calculating the effect that the slope and aspect of the ground have upon accumulated temperatures during the first 6 months of the year. Although the derived figures seemed sensible, at the time there was no means of verification. Since then Roe (1985) has made some ground level temperature measurements on a Welsh hillside which have been used to carry out an assessment of the model.

2. Differences Between the Model and Experimental Data

The basic information needed by the model from day to day is the grass minimum temperature and the sunshine. Neither of these was measured at the experimental site, but both were measured 2 km away at Trawscoed which is about 110 m lower. The difference in sunshine over the 2 km is likely to be small. It is possible that the grass minimum on the hillside was less than that at Trawscoed if lapse rate theory can be assumed to apply to the ground surface. However the 0.5°C reduction in grass minimum imposed by this could easily be outweighed by soil type and exposure altering the all-important radiative transfers. If Trawscoed was in a frost hollow for instance, the minimum temperatures at the ground on the hillside could be higher than those at Trawscoed. Because of these uncertainties the Trawscoed grass minima have been used as they stand to represent the hill site. Any errors introduced in this way will apply equally to all slopes, except when the T-sum is around zero, when any discrepancies will be small. Therefore relative differences between slopes will be virtually unaffected.

3. Comparison of Results

Figure 1 gives a graph showing the accumulated T-sums at weekly intervals from the hillside and the model. The difference between the T-sums for sloping ground and those for flat ground (as derived from the model since no flat surface measurements were made on the experimental site) are shown in Figure 2.

On the south site the discrepancies between the model and the measured data are due mainly to the accumulation lines (as shown in Figure 2) having different gradients in the spring, the model values increasing more steeply. This indicates that the calculated T-sums in this season are consistently higher than the measured values from day to day. Figure 3 (which gives the temperature difference between the model and the measured data as a percentage of the measured value) indicates that the calculated T-sums are consistently about 5% higher from April to June. With daily T-sums of about 6-10°C, this amounts to less than half a degree C per day. Such an error could be accounted for by the grass minima being lower on the hill site than they were at Trawscoed.

Figures 1, 2 and 3 all indicate that on a north facing slope there is good agreement between the model and actual T-sums, with differences frequently less than 5%.

From Figure 2 it is evident that the model shows very little difference between a flat surface and a surface sloping west at 20° although there is a trend towards the actual difference being larger. However the differences between the theoretical and measured values on a west facing slope are small in actual terms over the winter months(Fig 1) and in percentage terms (Fig 3), throughout the spring.

In Figure 4 the differences in the theoretical and actual T-sums values have been translated into days. After the initial over-sensitivity, caused by the T-sum differences being of similar magnitude to the T-sums themselves (although both being small in absolute terms), the differences settle down to generally less than 5 days, and are often only 2-3 days. There is a noticeable hiatus in the middle of March, where the calculated values appear to be abnormally low on all slopes. This was a period of very low grass minima (below -7°C on a few days) and much sunshine (clear skies) accompanied by light winds and stable night time conditions, ideal for phenomena such as cold air drainage. It is therefore possible that the minima at Trawscoed were anomolously low over this period, creating the depression in the calculated T-sums. On the north facing slope where the discrepancy is greatest, it amounts to a full 2°C per day over a period of two weeks.

4. Conclusions

The agreement between the theoretical and actual T-sum measurements is good for all the slopes of the hillside under examination.

On average the time difference between the T-sum reaching a certain value on the actual and theoretical surfaces is about 6 days from January to March and 2 days from April to June. Further experimental data would be needed to establish the reasons for the differences between the two sets of data.

5. References

Lee, M J 1984 The effect of aspect upon the temperature of the ground and associated changes in accumulated temperature - Agricultural Memorandum No. 1023 (unpublished).

Roe, C P 1985 Allowing for the effect of aspect of sloping ground on published ADAS T-sum figures - Agricultural Memorandum No. 1052 (unpublished).

KEYWORDS : T-sums, aspect, slope.

Any comments or suggestions on this paper should be referred to the author.

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FIGURE 1

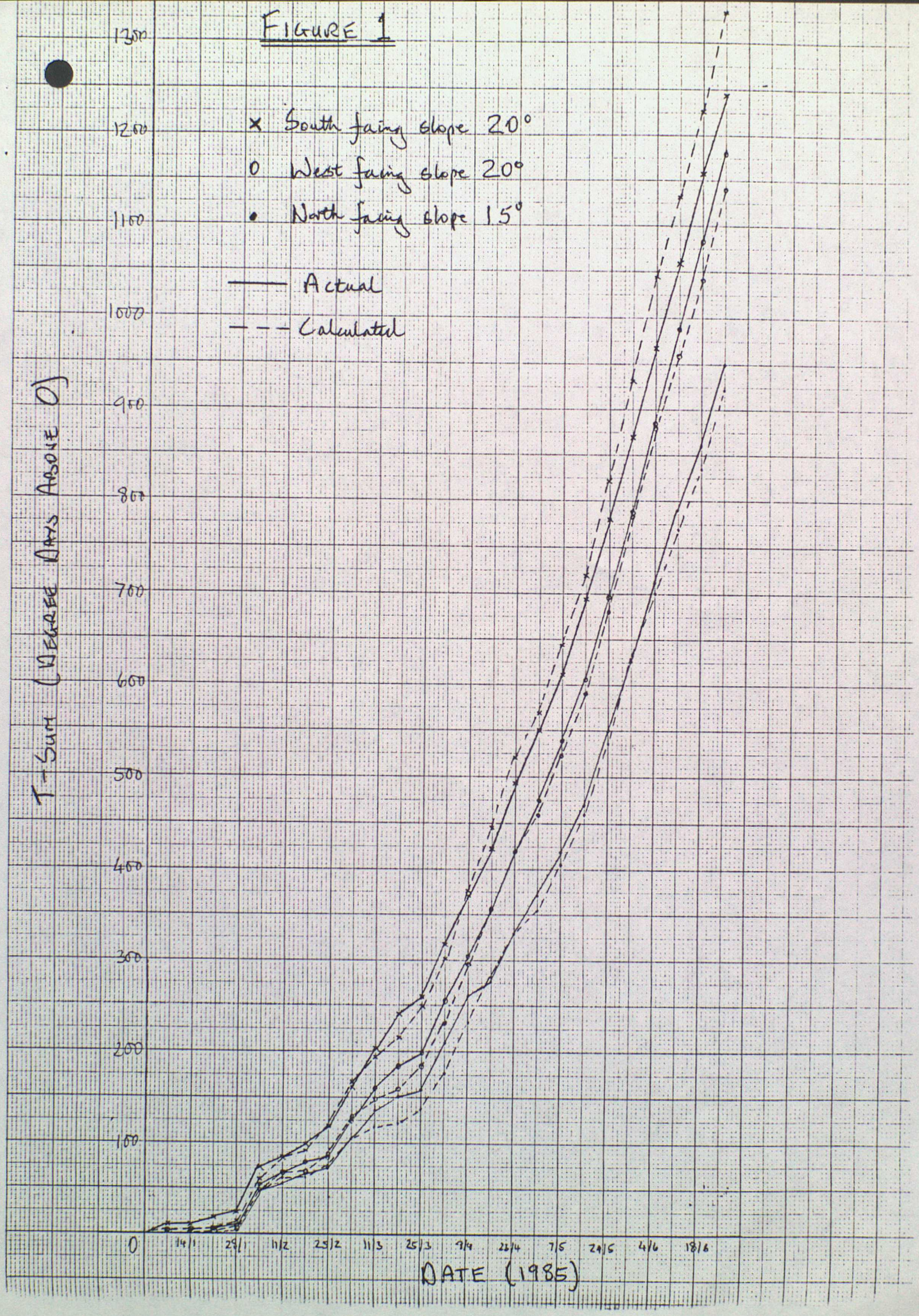

× South facing slope 20°
O West facing slope 20°
• North facing slope 15°
—— Actual
– – – Calculated
T-SUM (DEGREE DAYS ABOVE 0)
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
14/1
29/1
11/2
25/2
11/3
25/3
7/4
22/4
7/5
20/5
4/6
18/6
DATE (1985)

FIGURE 2

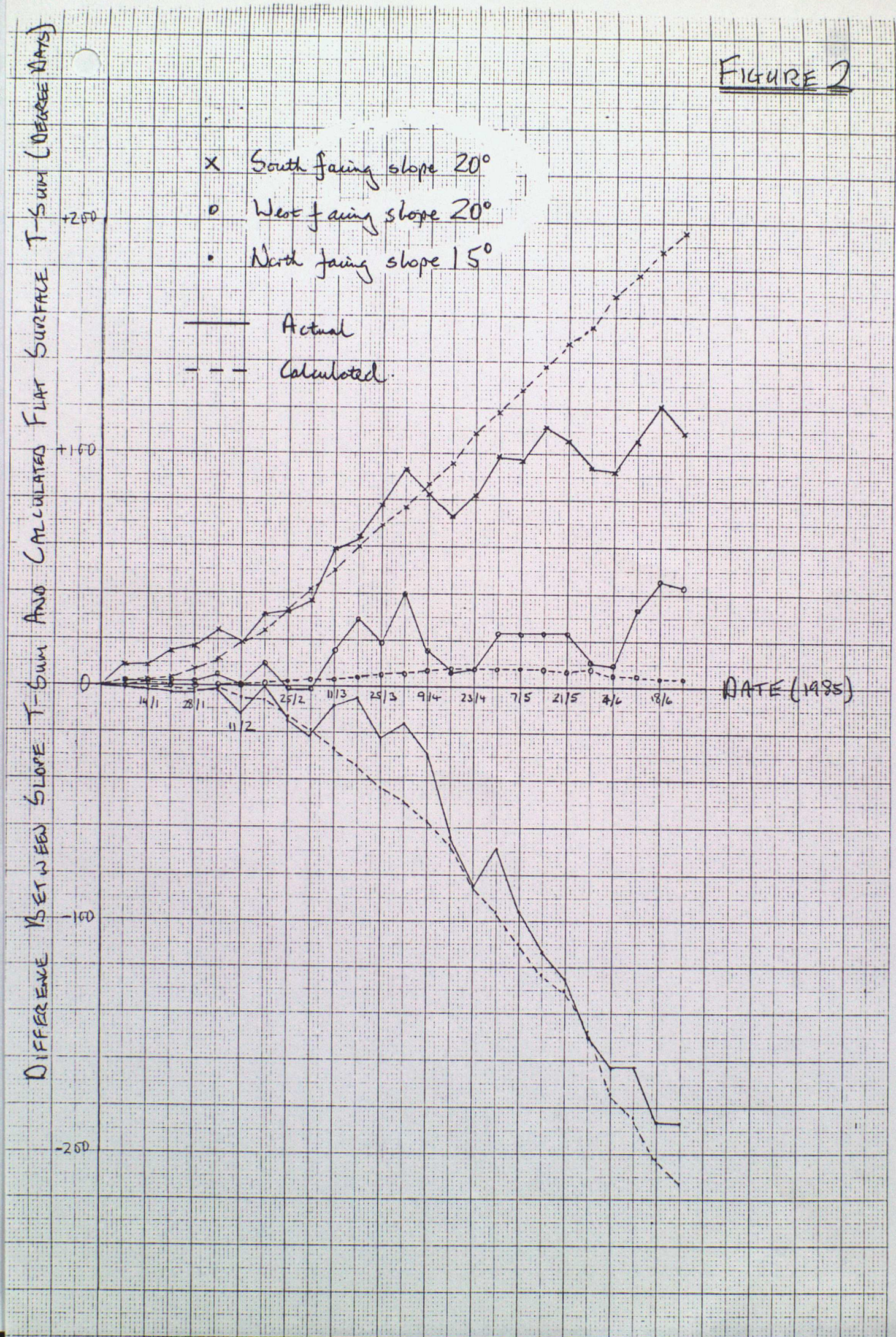

DIFFERENCE BETWEEN SLOPE T-SUM AND CALCULATED FLAT SURFACE T-SUM (DEGREE DAYS)
+200
+100
0
-100
-200
× South facing slope 20°
o West facing slope 20°
• North facing slope 15°
Actual
Calculated
14/1
28/1
11/2
25/2
11/3
25/3
9/4
23/4
7/5
21/5
4/6
18/6
DATE (1985)

FIGURE 3

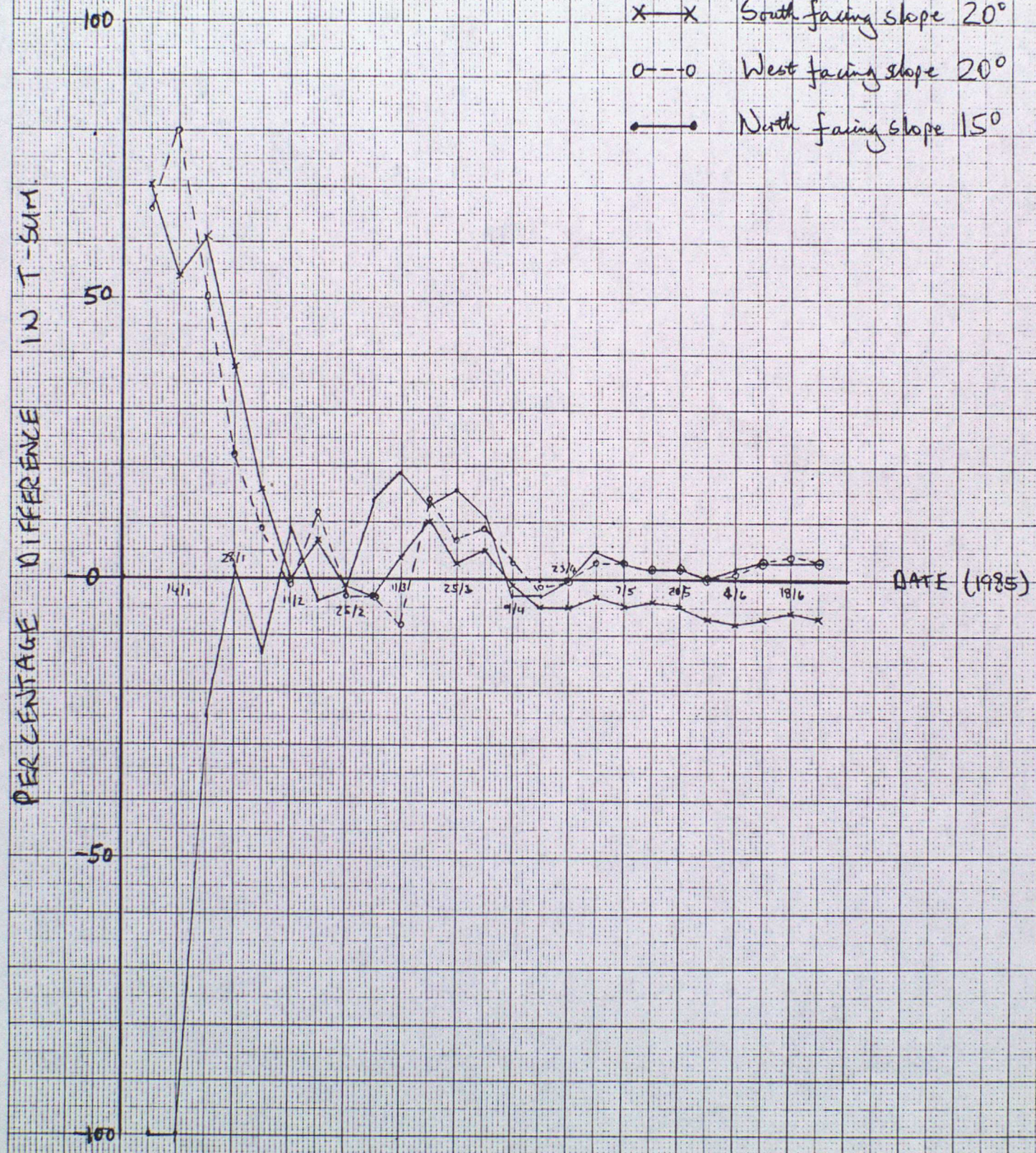
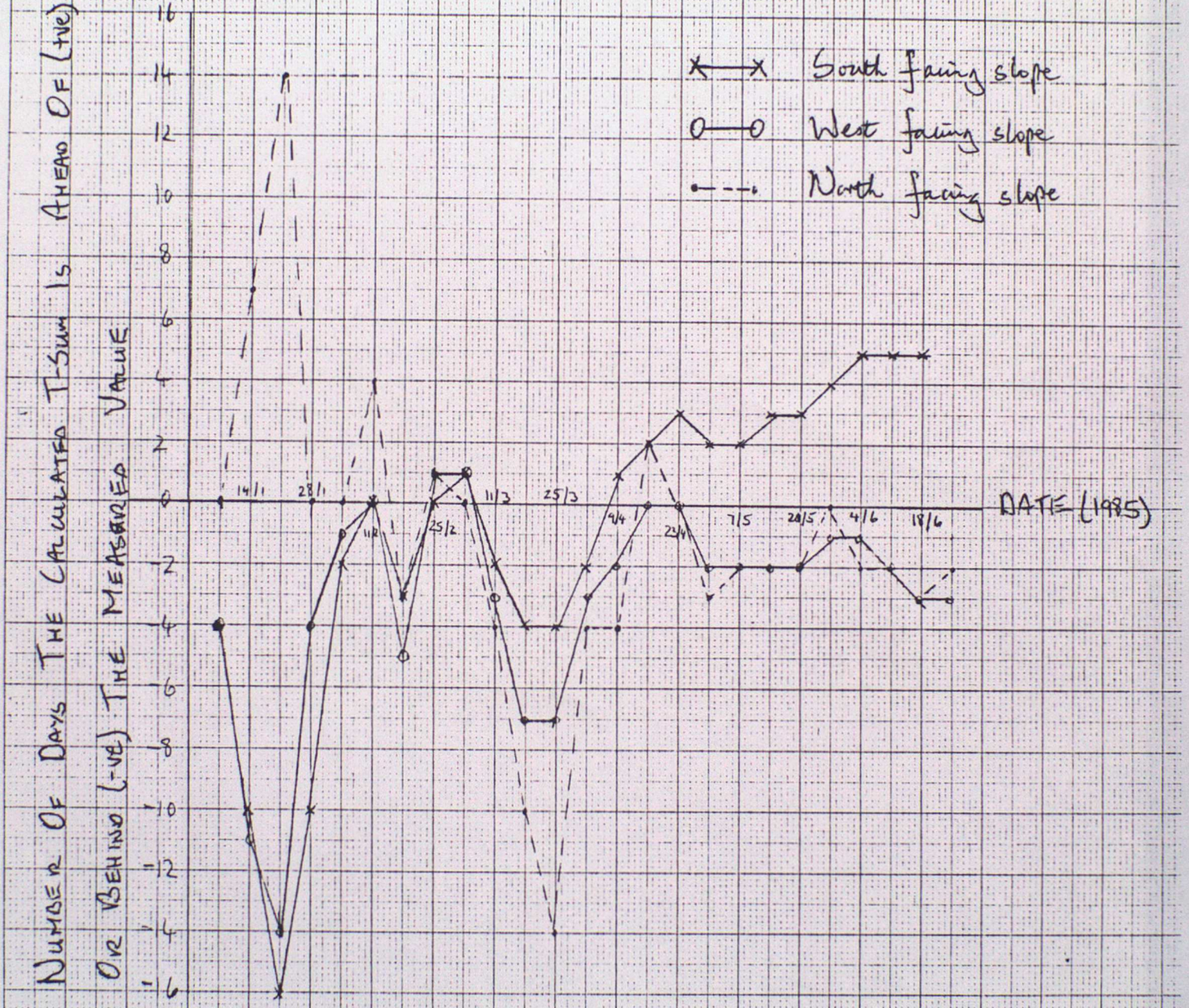

x—x South facing slope 20°
o---o West facing slope 20°
●—● North facing slope 15°
100
50
0
-50
-100
PERCENTAGE DIFFERENCE IN T-SUM
14/1
28/1
11/2
25/2
11/3
25/3
9/4
23/4
10
7/5
20/5
4/6
18/6
DATE (1985)

FIGURE 4


South facing slope
West facing slope
North facing slope
NUMBER OF DAYS THE CALCULATED T-SUM IS AHEAD OF (+VE) OR BEHIND (-VE) THE MEASURED VALUE
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
14/1
28/1
11/2
25/2
11/3
25/3
9/4
23/4
7/5
20/5
4/6
18/6
DATE (1985)